

# ***POST-***

# **The Pacific Ocean Shelf Tracking Array... & Relevance to NOAA's Mission**

**David Welch**

# Summary of Talk

- *A Description of POST*
- *How POST Works*
  - *Tagging, Array Design, Array Operation*
- *Some Case Studies*
  - *Snake/Columbia R Salmon Smolt Survival*
  - *Columbia vs Fraser R Salmon Smolt Survival*
  - *The Late-Run Fraser Sockeye Problem (Adults)*
- *Some Potential Applications of POST*
  - *Adult Salmon*
  - *Sablefish*
  - *Dogfish*
  - *OOS (Ocean Observing Systems)*

# What is POST?

**Goal:** To develop a continental scale ocean monitoring network for the West Coast of North America

**Where?** On the sea-bed of the continental shelf & slope— and major rivers

**How?** Using recent advances in low-power electronics & acoustic telemetry

**Why?** Information needs in fisheries & marine science not met by current capabilities

# Why Bother?

- **Huge Hidden Costs** Not having info on movements & survival means huge costs:

- **Movements**

- Failure of Stock Assessment Models
- Lack of Appropriate Jurisdiction & Control (Fish don't obey political boundaries; Restrictions in One Country may Benefit Another Country).

- **Survival**

- Changed Survival (Climate Change) means Shifting Baselines
- Harvest Rates should change, yet Stock Assessments are retrospective, and do not generally reflect this year's conditions

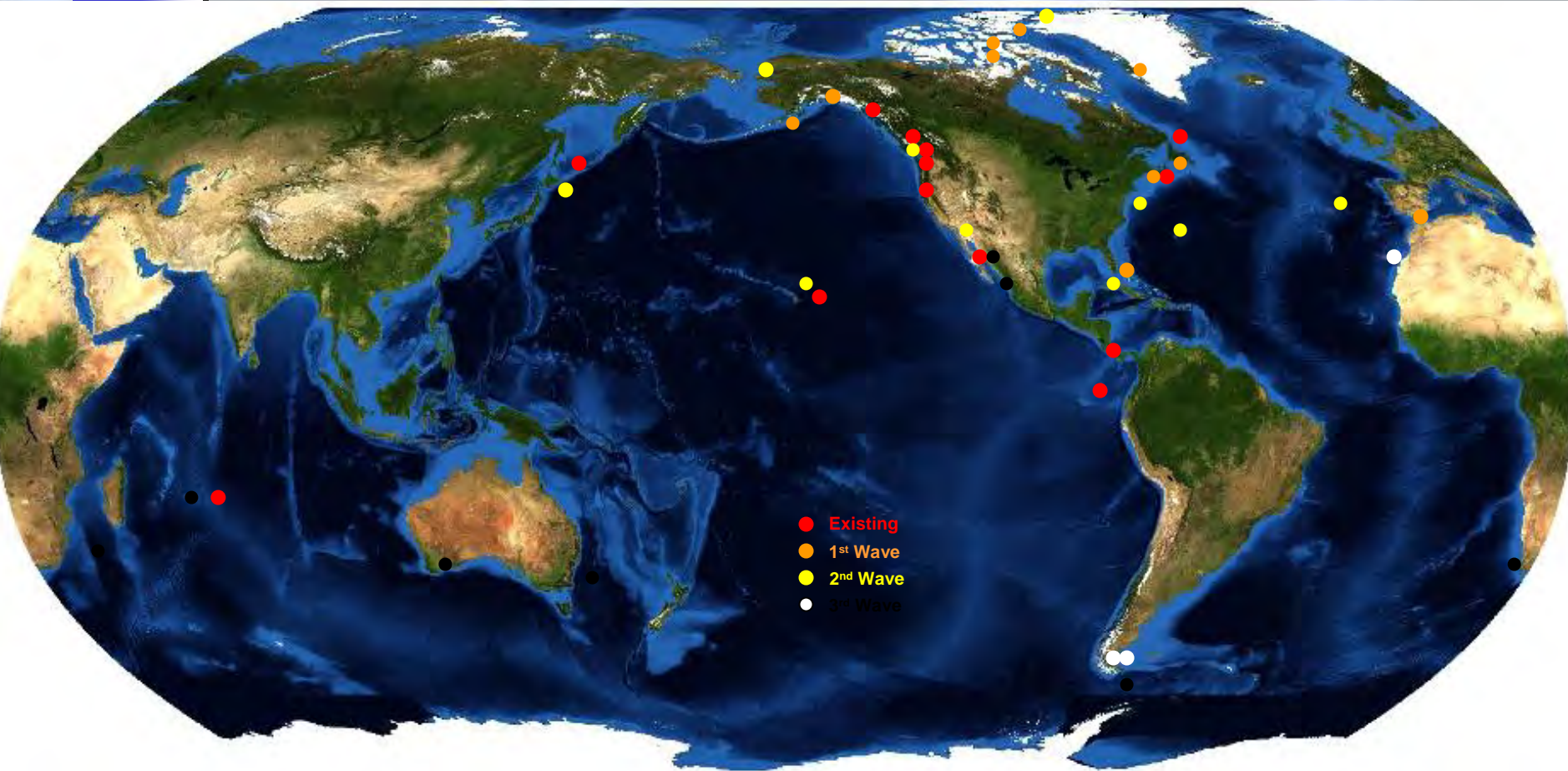
- **Opportunity Costs**

- Costly staff spend time and money not addressing the key issues

# Goals ...

- Understand how marine fish such as salmon use the shelf environment.
- Deploy a permanent continental-scale tracking array to directly measure the movements, distribution & survival of fish in the ocean
  - Movements/Migration
  - Spawning/Feeding Grounds
  - Marine Survival
- Use the platform as the basis for coastal GOOS
- Extend the technology to coastal seas around the world

# The Evolution of POST...the OTN

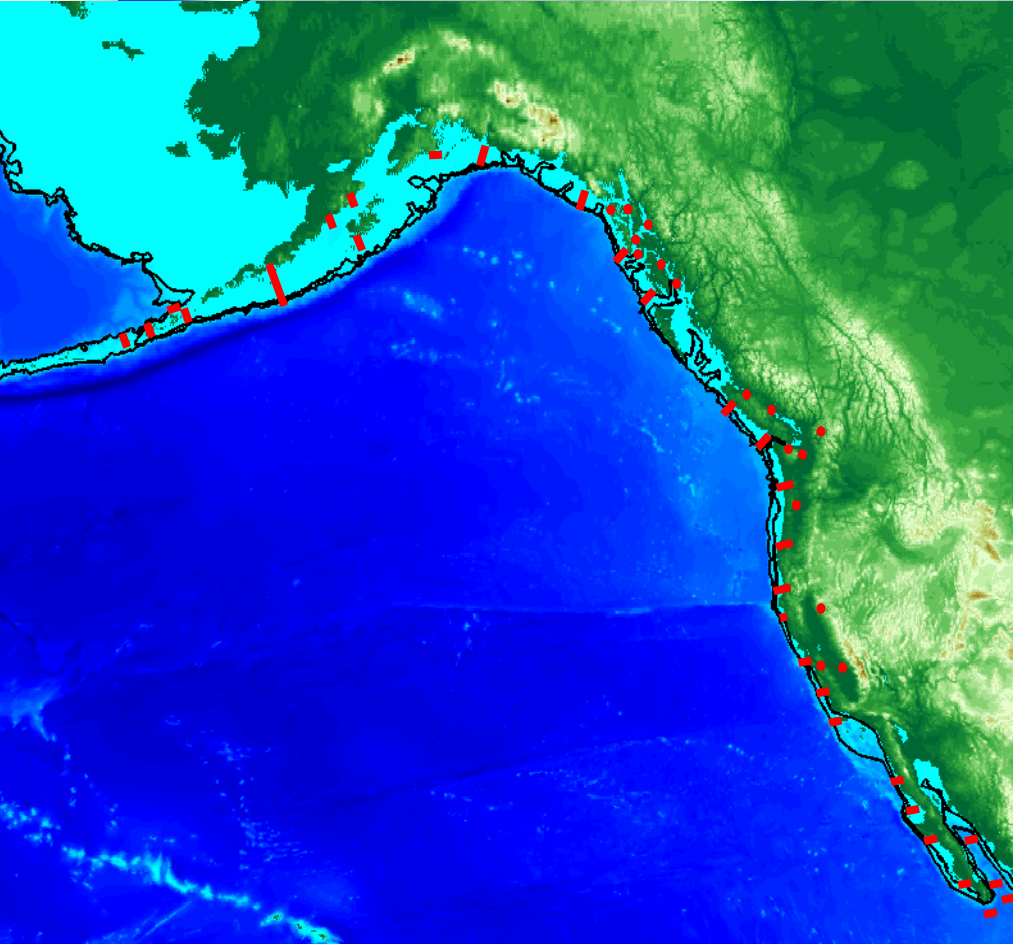


## the Ocean Tracking Network

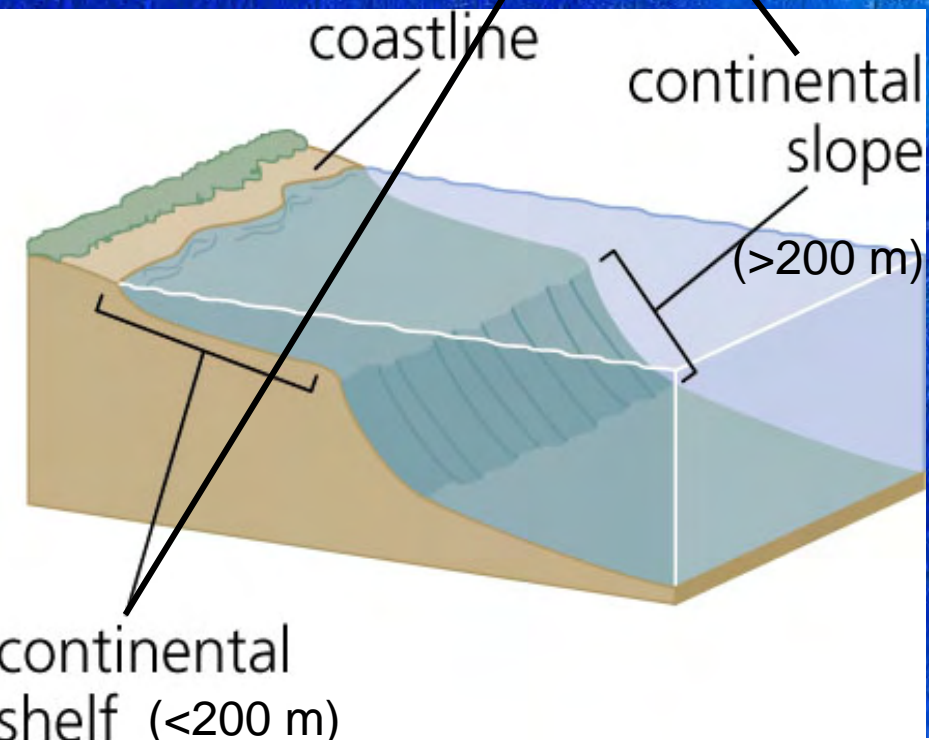
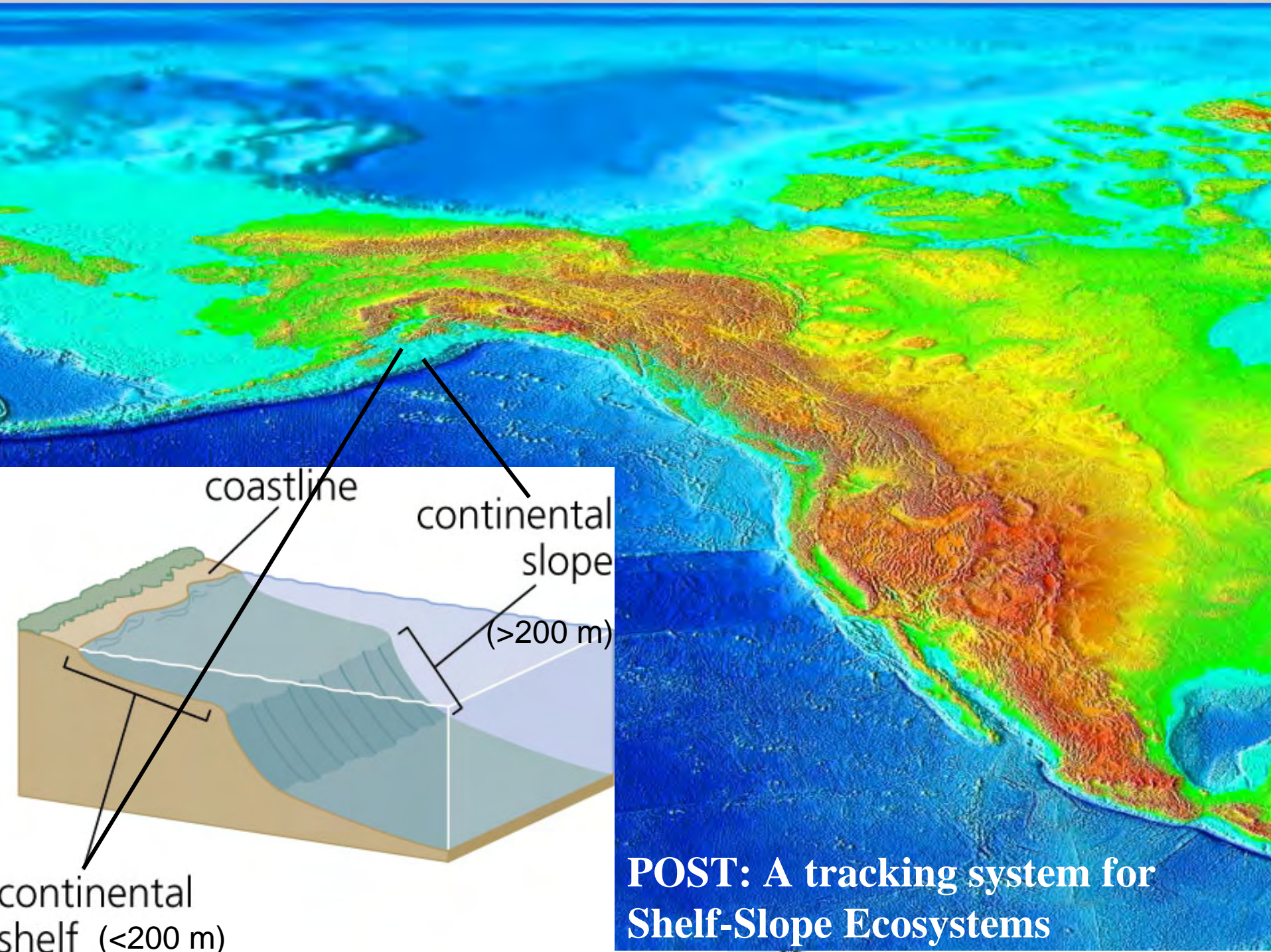
# Three Components to POST

1. Deploy a near-perfect array of “acoustic curtains” on the seabed
2. Surgically implant thousands of fish with individually identifiable acoustic tags
3. Deliver the data from the array to:
  - a. Prove the concept
  - b. Establish the technical platform
  - c. Generate scientific support & demand for the data

# Goals of the POST Project

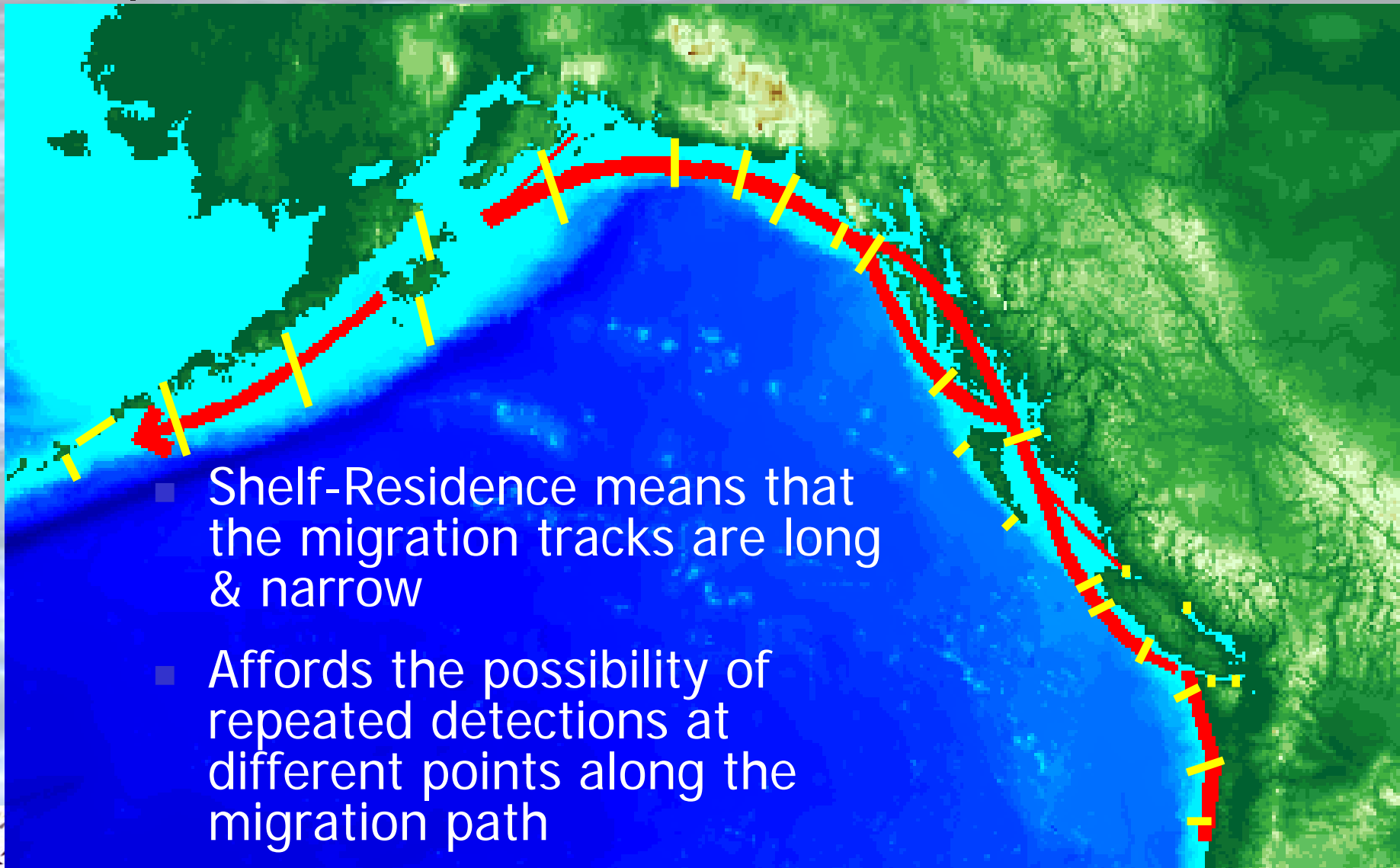


- A permanent continental-scale array
- Directly measure movement, distribution and survival of fish-including salmon- in continental shelf waters
- Develop the ability to follow individual fish– or separate stocks – for decades.
- (Expand the scientific observations to encompass a much wider range of oceanographic observations)



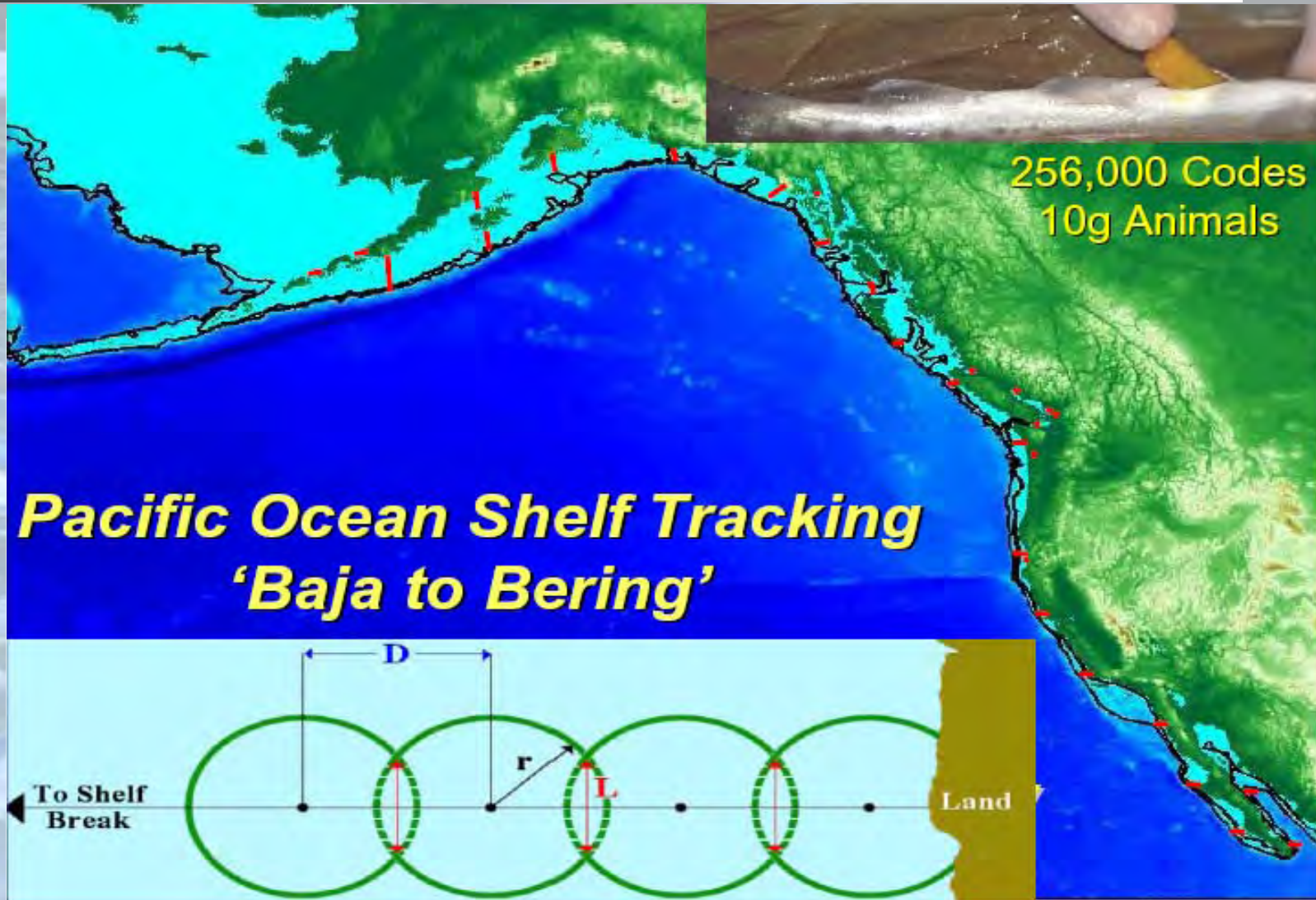
**POST: A tracking system for Shelf-Slope Ecosystems**

# How do we track acoustically-tagged animals along the continental shelf?



- Shelf-Residence means that the migration tracks are long & narrow
- Affords the possibility of repeated detections at different points along the migration path

# Designing & Building POST



# How to Track Salmon Movements on the Shelf?

- Surgically implant individual fish with a unique identifying tag
- Follow the tagged fish with a tracking array to reconstruct their movements
- Advantages:
  - 1. Never have to catch the fish again.
  - 2. Reconstruct movements over an entire lifetime.

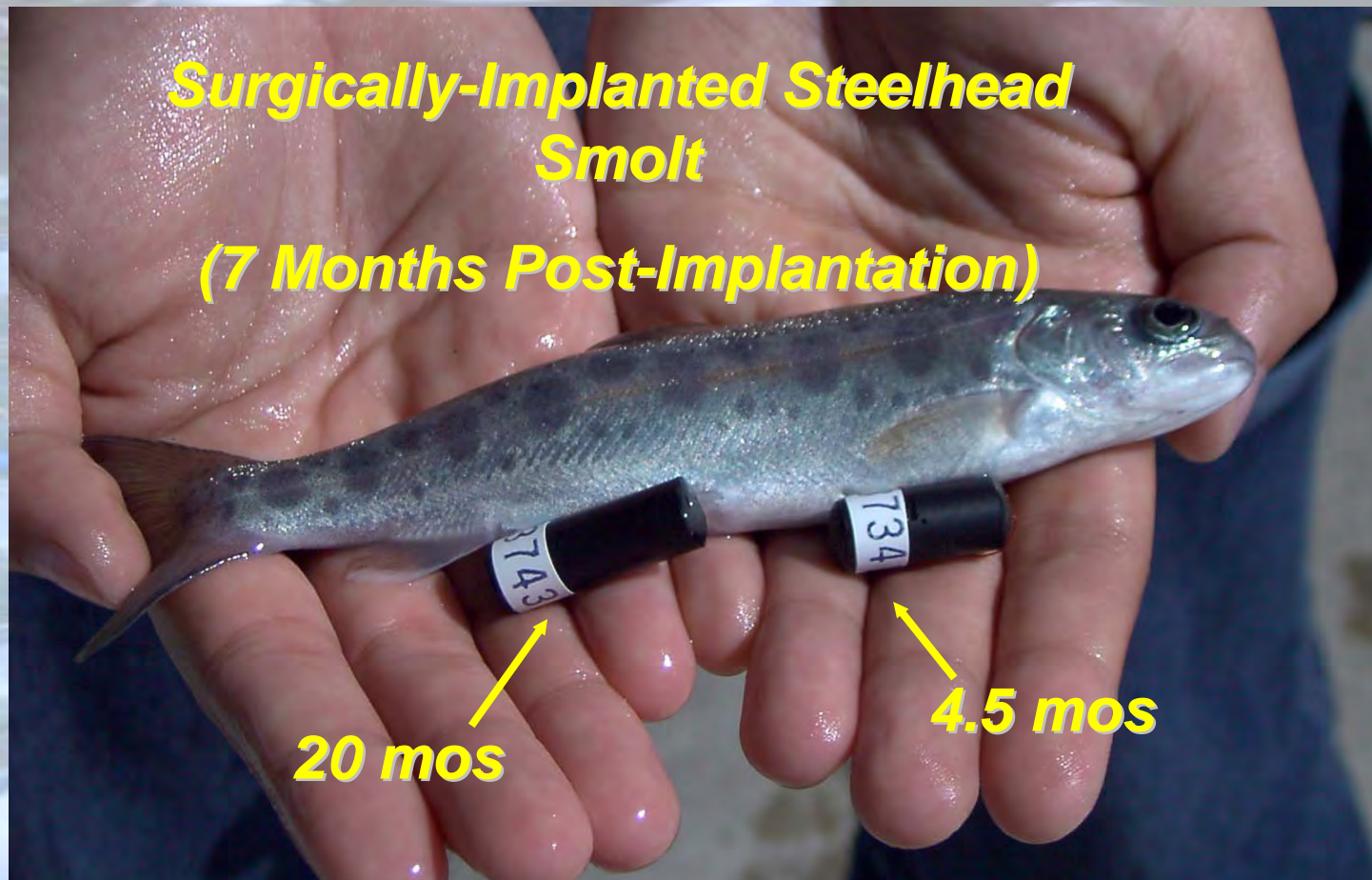


## Even small fish are candidates for acoustic tagging



# Acoustic Tags for Small Fish

- Tags with lifespans of 1 to 20+ years are now feasible
- Multi-decadal tracking of fish will be critical to establish how climate change impacts individuals





**Field Tagging of Vancouver Island Steelhead Smolts,  
Project POST**

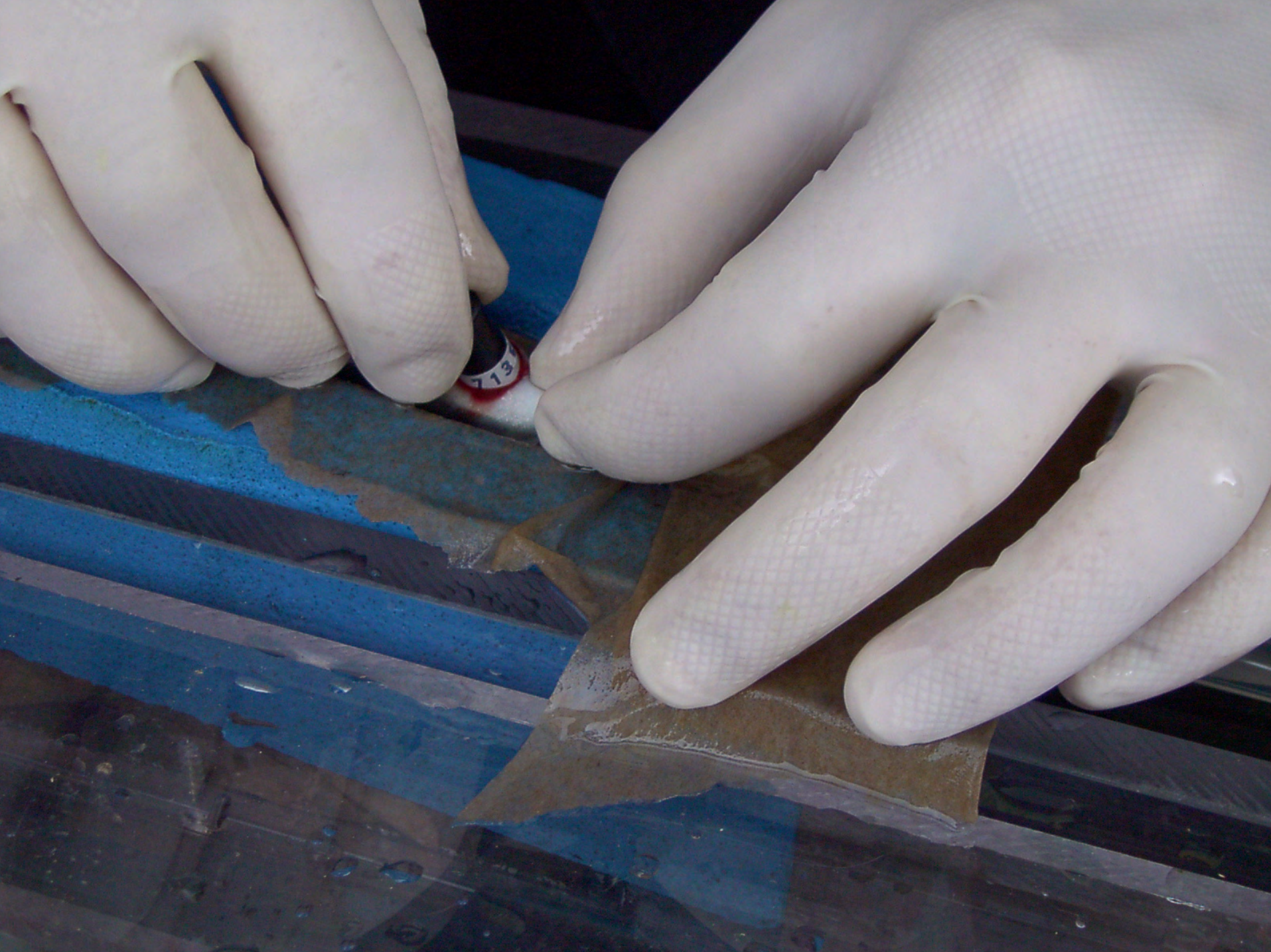












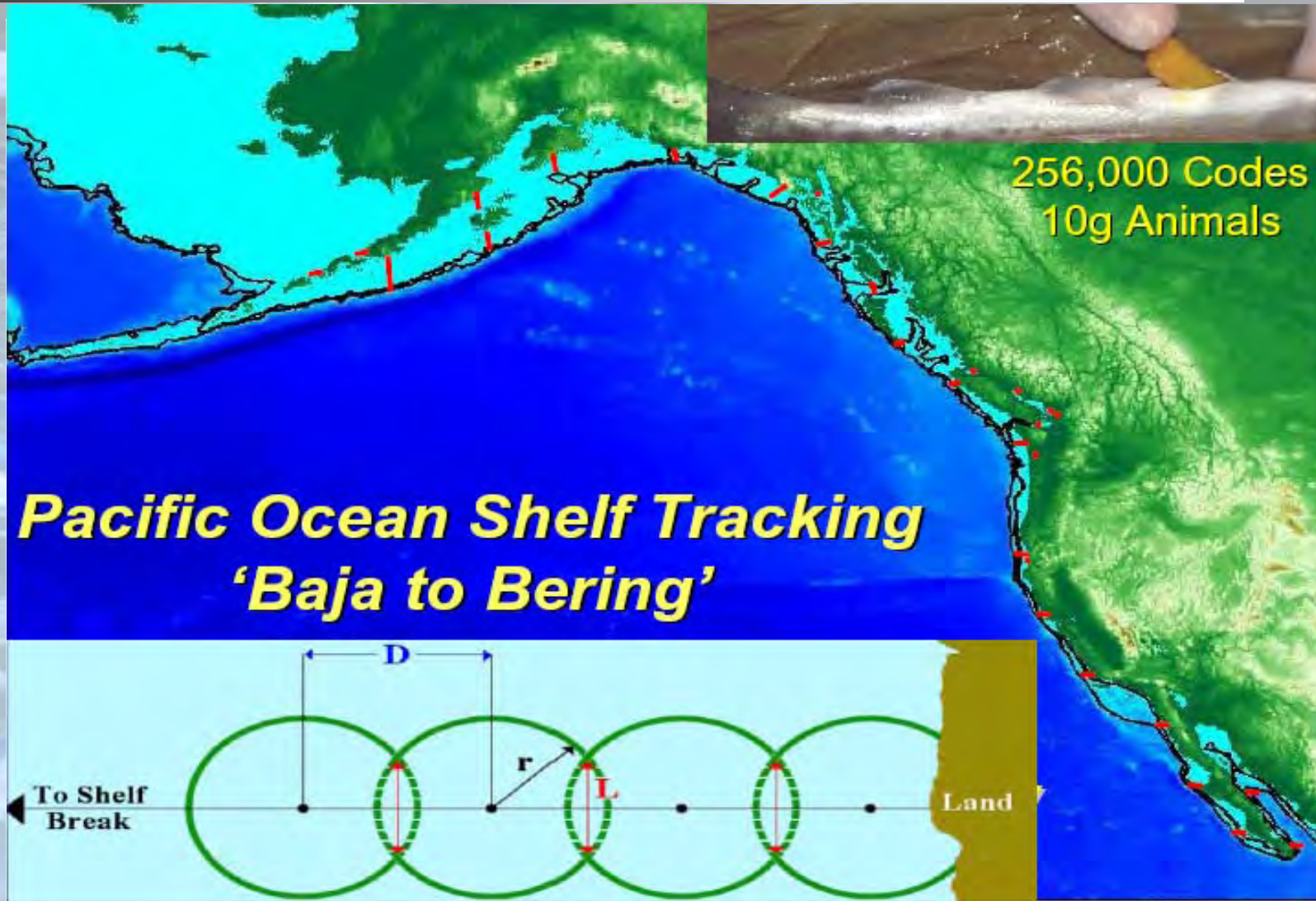




# Building the Array

- Key goal is to identify an “optimal” array geometry & tag programming while:
  - Minimize capital cost of array
  - Maximize detection efficiency
  - Maximize lifespan of tags tracked over the array
- Develop a way to deploy (& retrieve!) the prototype array
- Develop a permanent, long-lived, “wireless” system– lower costs, increase data recovery
- Transition to a smoothly operating, well-engineered system

# Designing & Building POST



# POST Team at Work



# POST Team at Work



# Deployment of Listening Lines (2004-05)





# 2006: Rollout of POST's Permanent (7yr), Wireless Platform





# 2006: Rollout of POST's Permanent (7yr), Wireless Platform



# Where POST is Going: Large Rivers

## Satellite- or Cell-Phone Linked Acoustic Sensors

- Two satellite based units deployed in the mouth of the Fraser & Columbia Rivers
- Eventually we will switch to a cell phone based SMS system for real time info
  - Above water antennae allows tagged fish to email their arrival times (and survival!)
  - Also provides ability to measure survival in/out of large rivers
  - Many applications to listed salmon stocks in rivers

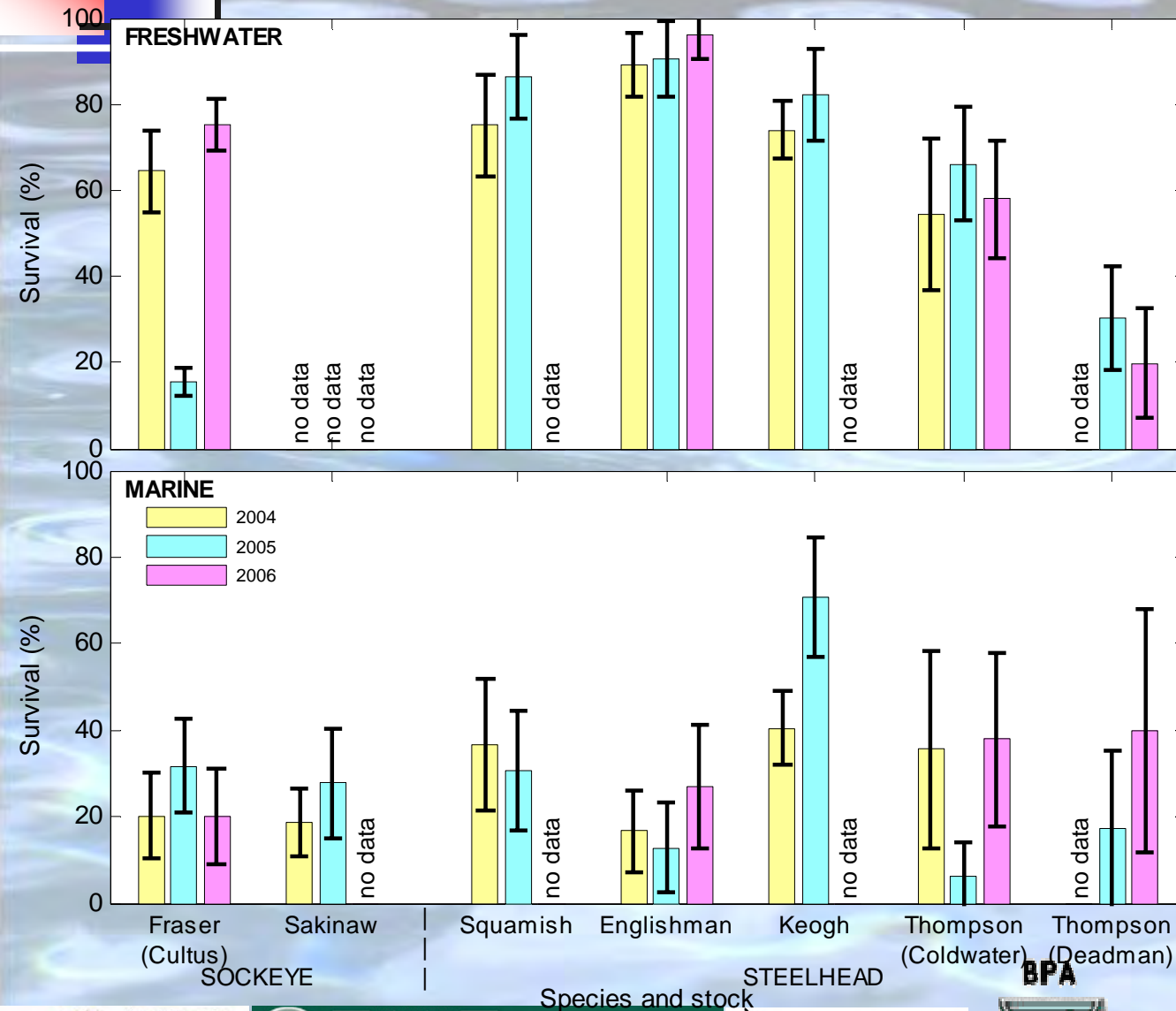


# POST Array- 2006-07 Overwinter Performance

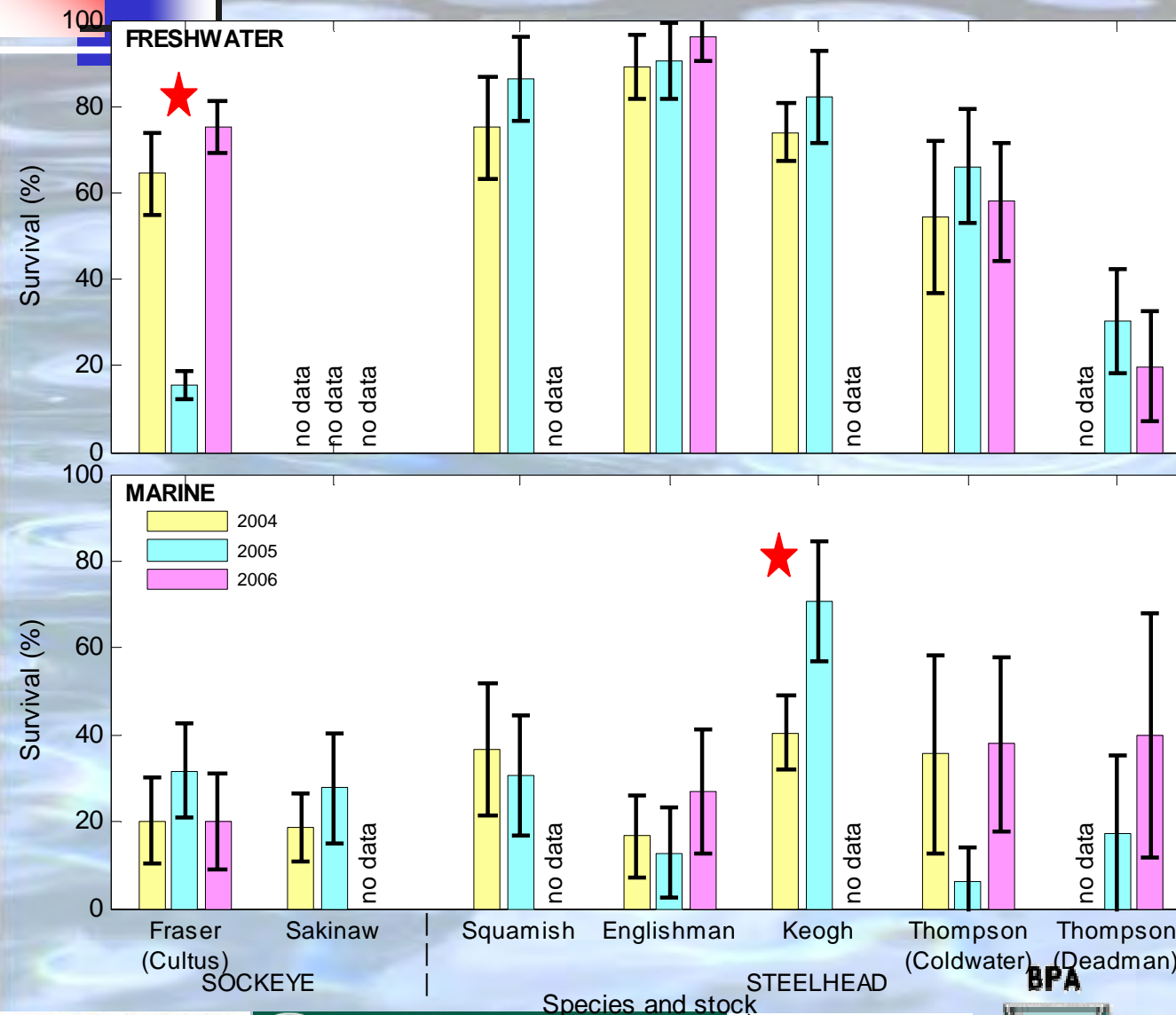
- Most permanent equipment survived the winter
- Attrition rates look "reasonable", although some minor loss to trawlers
- Now need to garner data for long-term performance assessment
- Detection efficiency of 20 km listening lines at ~95%



# BC Salmon Survival Freshwater & Marine



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Only two stocks show differences in survival between years:

1. Cultus L sockeye FW survival in 2005 was 1/6<sup>th</sup> that measured in 2004
2. Keogh R steelhead marine survival higher in 2005 than 2004
3. All other survival measurements stable between years, suggesting that what we are measuring is "real".

# Application of POST to Columbia R. Salmon Management Issues

# Example: Snake R Chinook

## Status:

- *Listed as endangered under ESA*

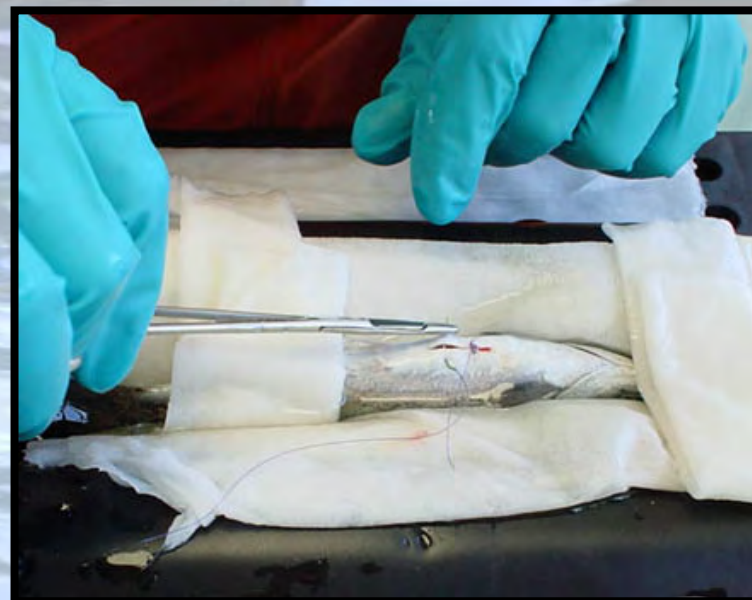
## Issues:

1. *Cause of poor adult returns unclear*
2. *Other, apparently similar, up-river stocks have much better survival*
3. *Does barging smolts past dams help or hurt?*

# The 2006 POST Array



# 2006 Tagging



Spring chinook tagged in 2006

	ROR 1	ROR 2	BARGED 1	BARGED 2	Total
Yakima	200	200	na	na	400
Snake	200	200	100	100	600

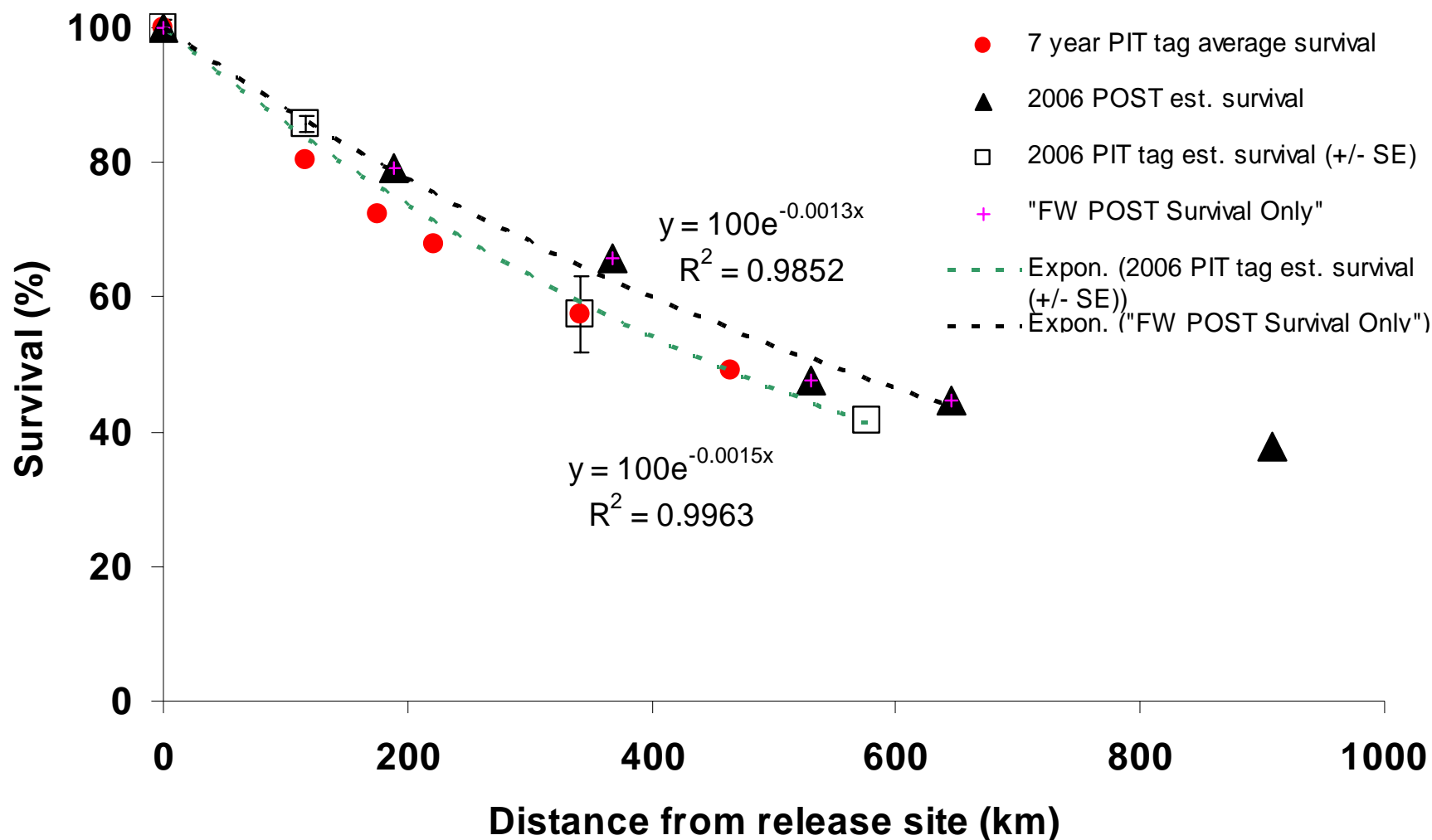
# Snake R Movements

## Animation of Snake R Smolt Movements

File: Snake\_2006\_ROR&barged.avi

# Tag Effects:

## (1) Relative In-river Survival



# 2. Survival: Delayed Mortality

- *Minimum survival estimates at*
  - *Willapa Bay (960 kms from Snake R release site)*
  - *NW Vancouver Island (NWVI; 1,500 kms)*
- *These are minimum estimates of survival*
  - *Lost gear\*\**
  - *Detection efficiency (~95%)*
  - *Tag retention/survival (~85%)*



# Delayed Mortality Results (Average Surv $\pm$ 1SE)

- Snake R survival the same as or higher than Yakima R stock

	Yakima ROR	Snake ROR
"FW" Survival (to Willapa Bay)	19.8 $\pm$ 2%	18.9 $\pm$ 2%
Ocean Survival (Willapa Bay to NWVI)	2.5 $\pm$ 1.8%	5.3 $\pm$ 2.6%
Net Survival from Release to NWVI	0.5 $\pm$ 0.4%	1.0 $\pm$ 0.5%

BPA

# Transport (Average Survival $\pm 1\text{SE}$ )

➤ Barged survivals >2X ROR smolts

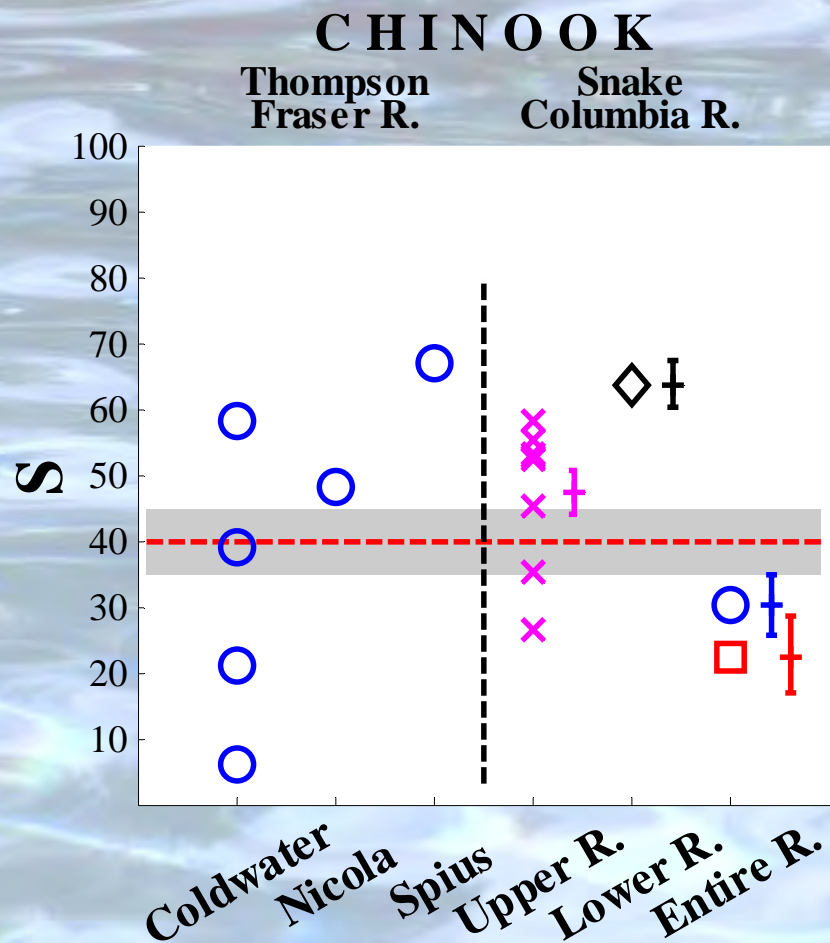
	Yakima ROR	Snake ROR	Snake Barged
"FW" Survival (to Willapa Bay)	$19.8 \pm 2\%$	$18.9 \pm 2\%$	$37.9 \pm 3\%$
Ocean Survival (Willapa Bay to NWVI)	$2.5 \pm 1.8\%$	$5.3 \pm 2.6\%$	$14.3 \pm 4\%$
Net Survival from Release to NWVI	$0.5 \pm 0.4\%$	$1.0 \pm 0.5\%$	$5.4 \pm 1.6\%$

BPA

# A Comparison of Thompson & Snake R Salmon Survival

# Thompson (Fraser R) vs Snake (Columbia R) Survival- 1

Survival



BPA

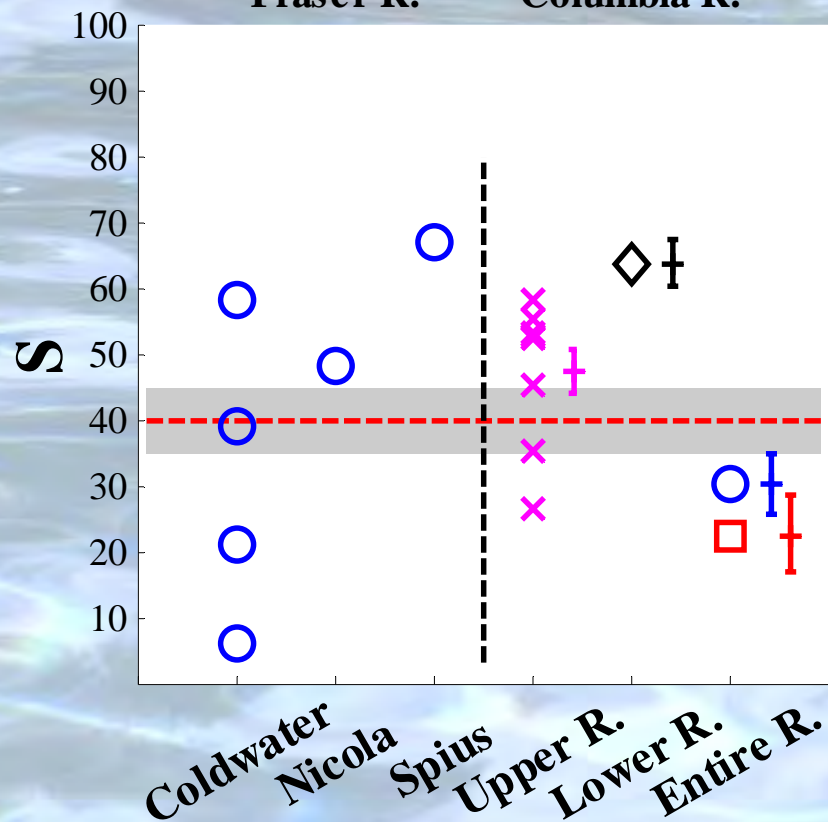
# Thompson (Fraser R) vs Snake (Columbia R) Survival- 1

## Survival estimates

### CHINOOK

Thompson  
Fraser R.

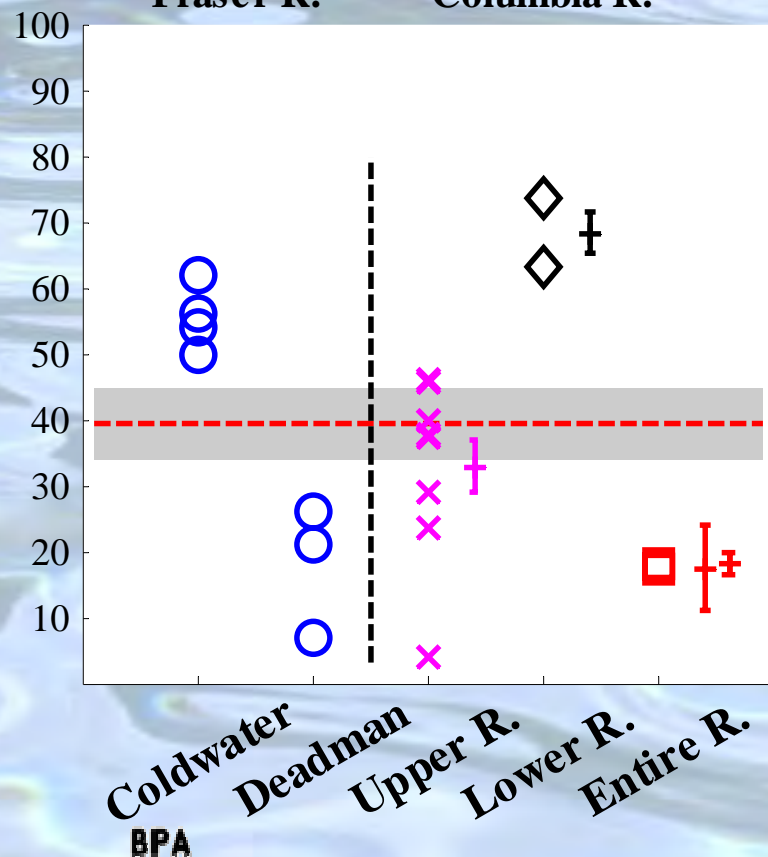
Snake  
Columbia R.



### STEELHEAD

Thompson  
Fraser R.

Snake  
Columbia R.



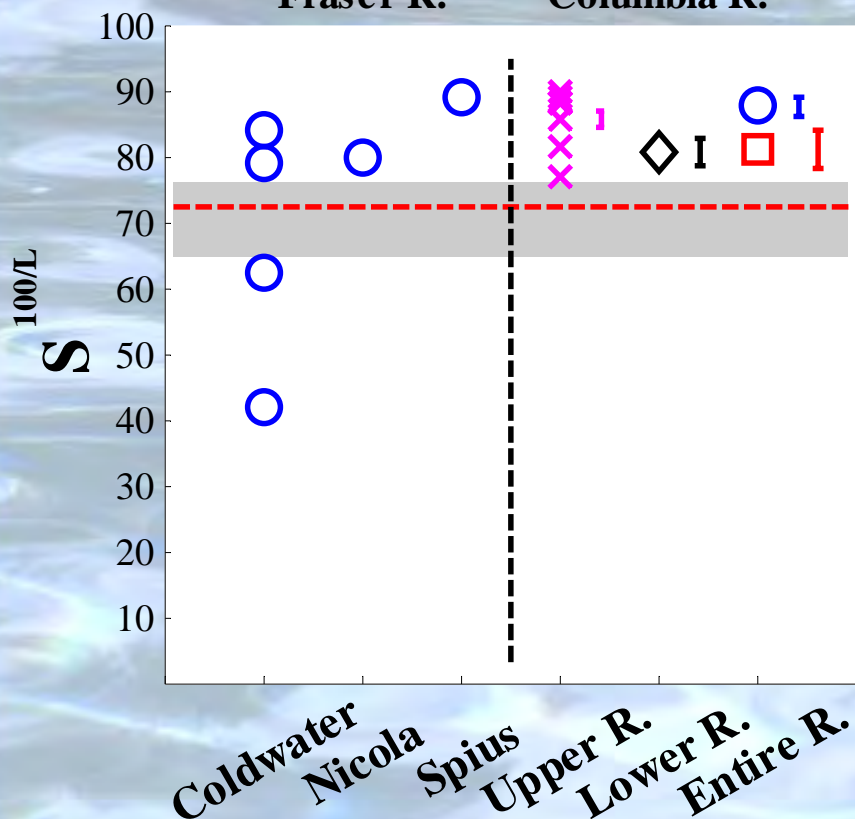
# Thompson (Fraser R) vs Snake (Columbia R) Survival - 2

## Survival estimates scaled by distance

### CHINOOK

Thompson  
Fraser R.

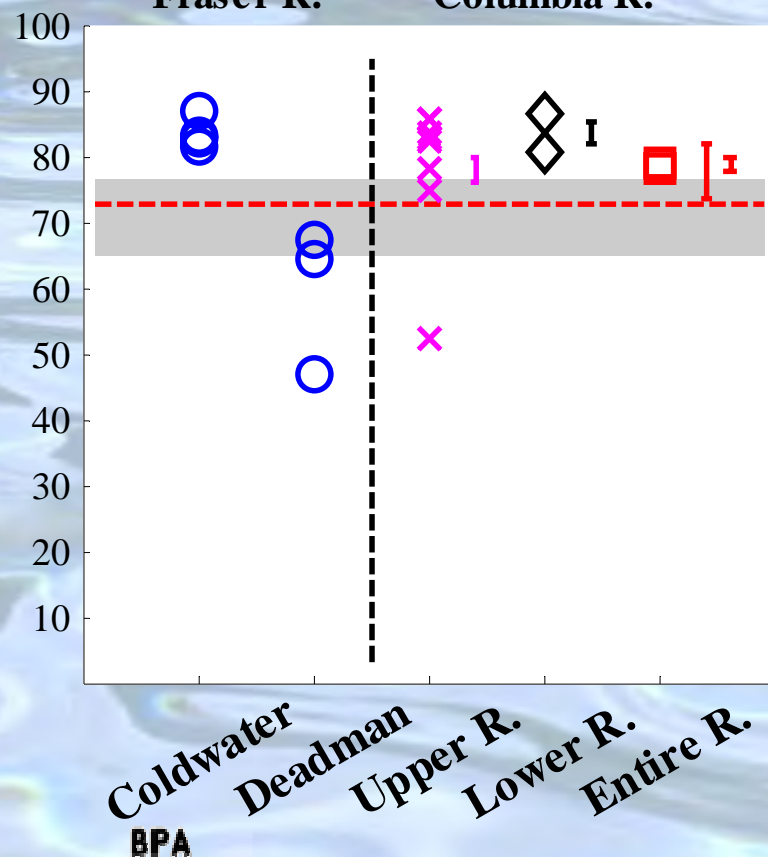
Snake  
Columbia R.



### STEELHEAD

Thompson  
Fraser R.

Snake  
Columbia R.



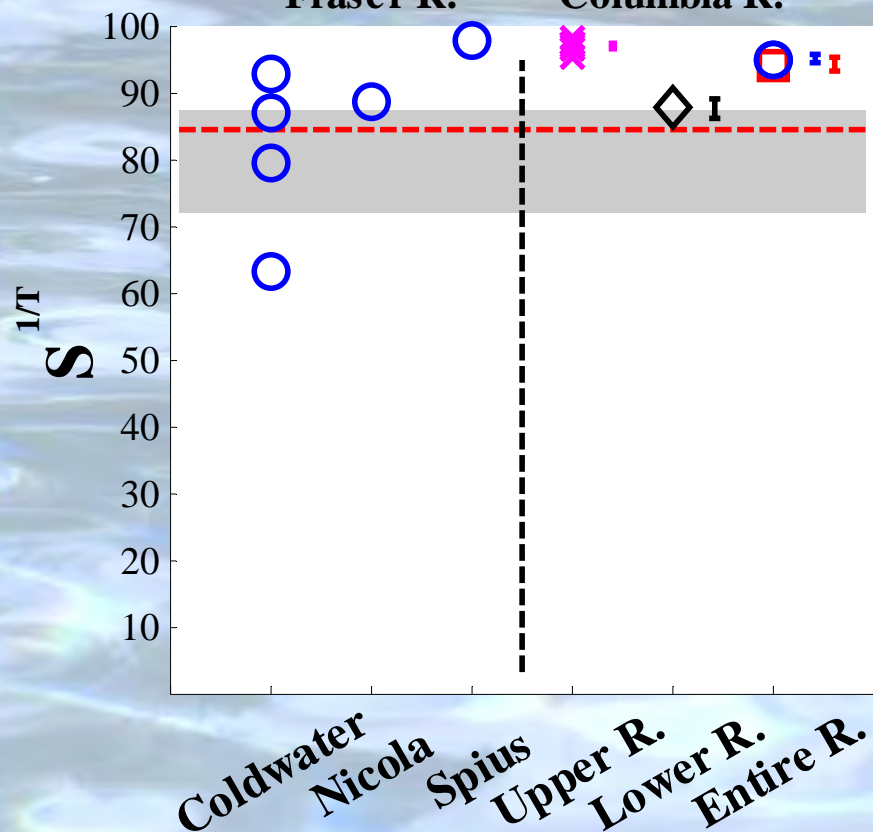
# Thompson (Fraser R) vs Snake (Columbia R) Survival - 3

## Survival estimates scaled by time

### CHINOOK

Thompson  
Fraser R.

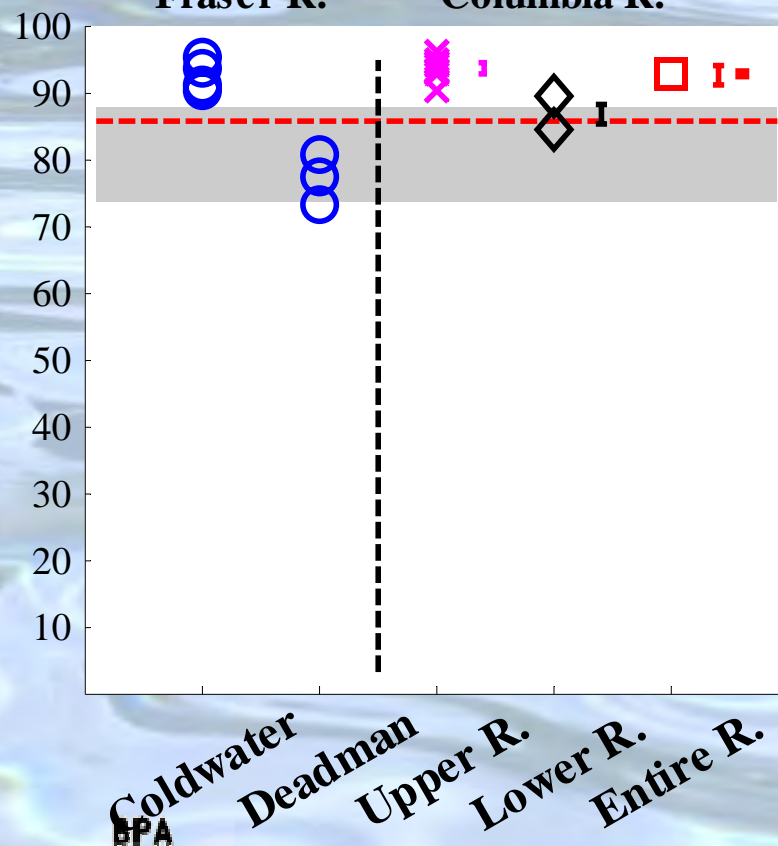
SNAKE  
Columbia R.



### STEELHEAD

Thompson  
Fraser R.

SNAKE  
Columbia R.



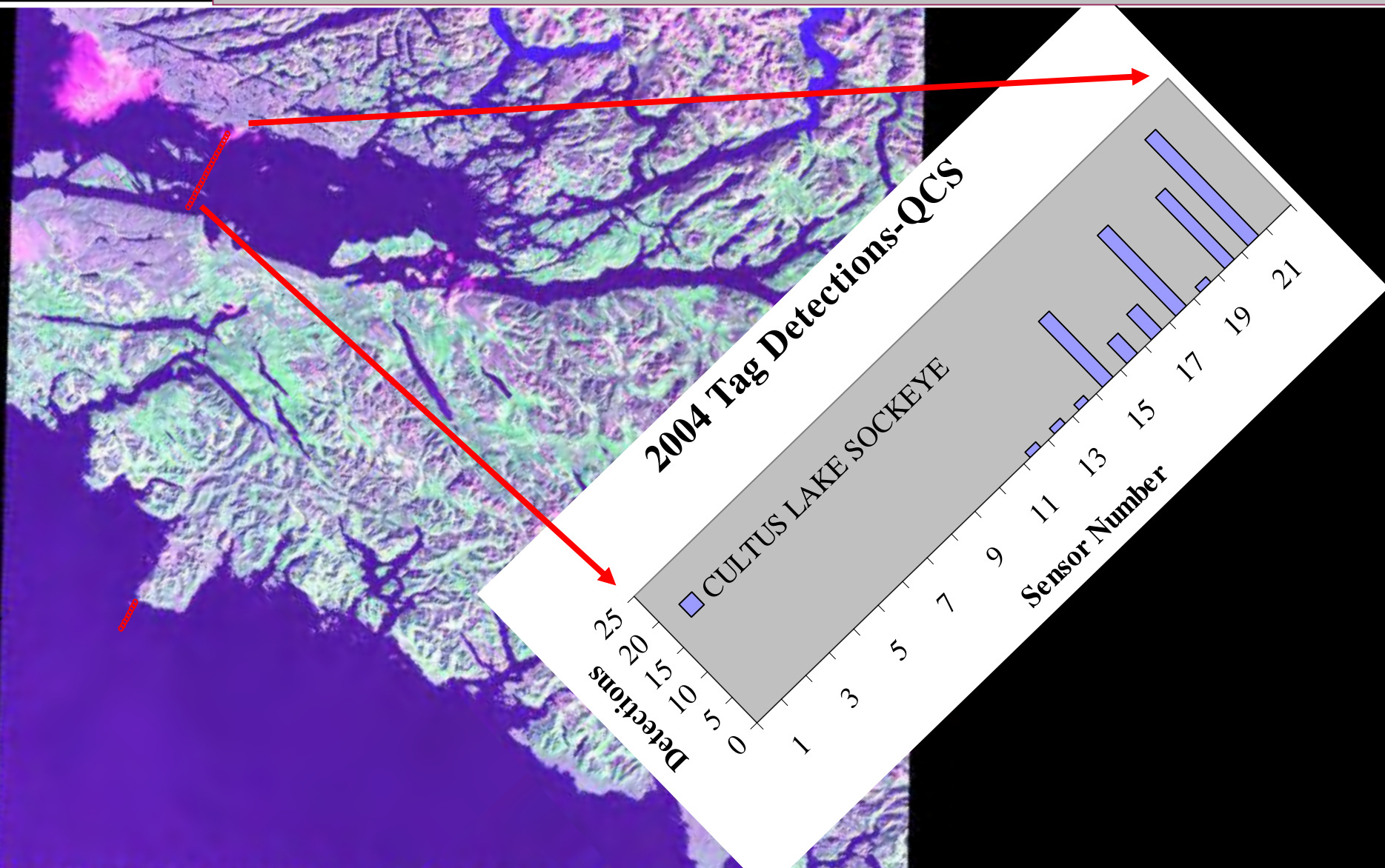
# Thompson vs Snake R Survival: The Big Policy Questions

- One River has 8 Dams, the Other has None.
- Why is Survival Apparently Better in the dammed river— And Why?
- What is the Role of the Ocean vs FW Habitat on Salmon Stock Status?
- What Problems can be Addressed (Mitigated) and Which Ones do we Adapt to?
- In the US, ca. \$700M/yr is spent on salmon rehabilitation work
- (In the Columbia alone, the true cost of addressing the salmon problems may be close to \$500M year)

# A Canadian Example: Cultus & Sakinaw Lake Sockeye

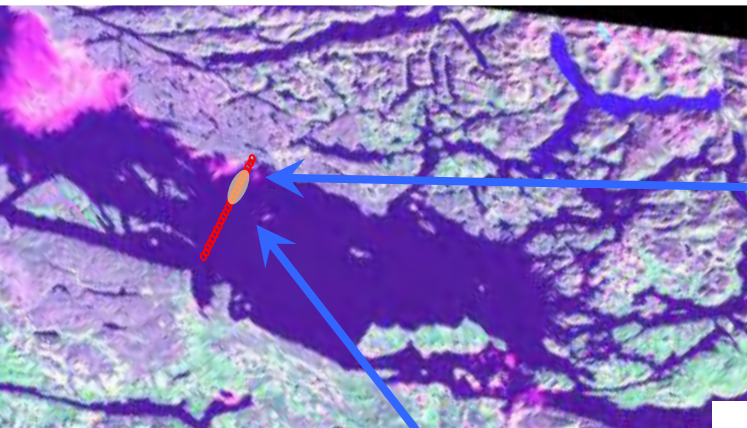
- 2004 animation of smolt out-migration
- 2005 animation of smolt out-migration

## 2. Sockeye Migration Routes- Queen Charlotte Strait Listening Line

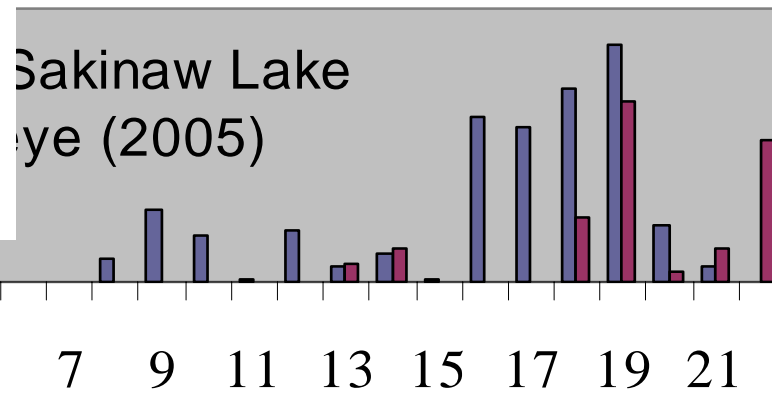
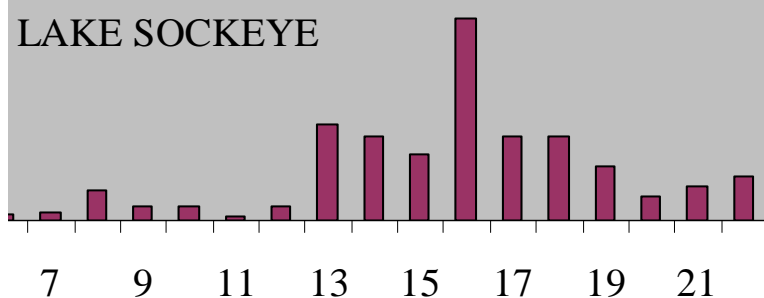
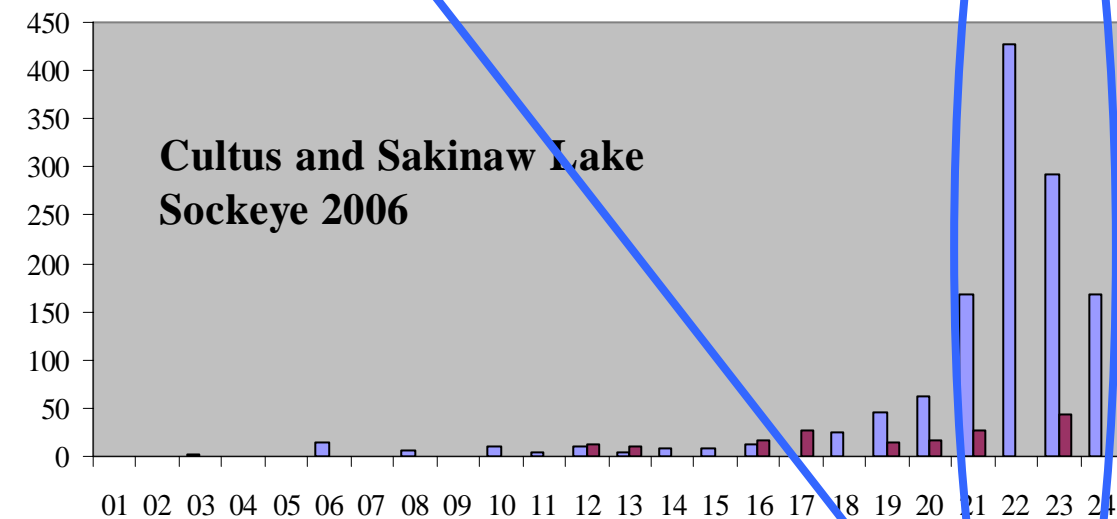
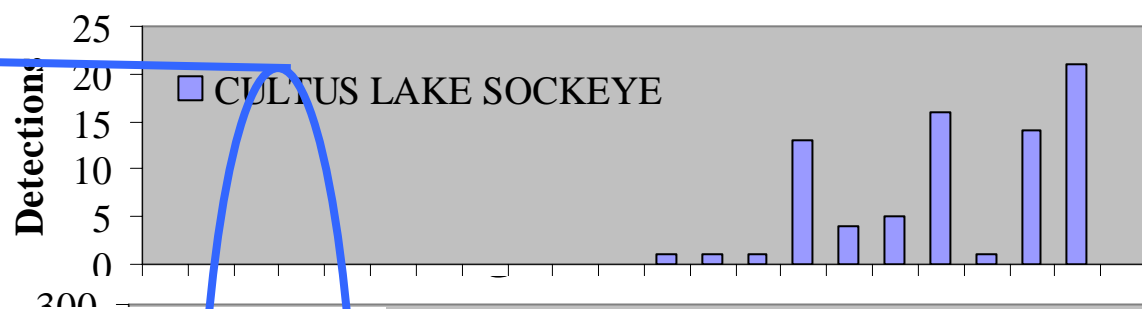




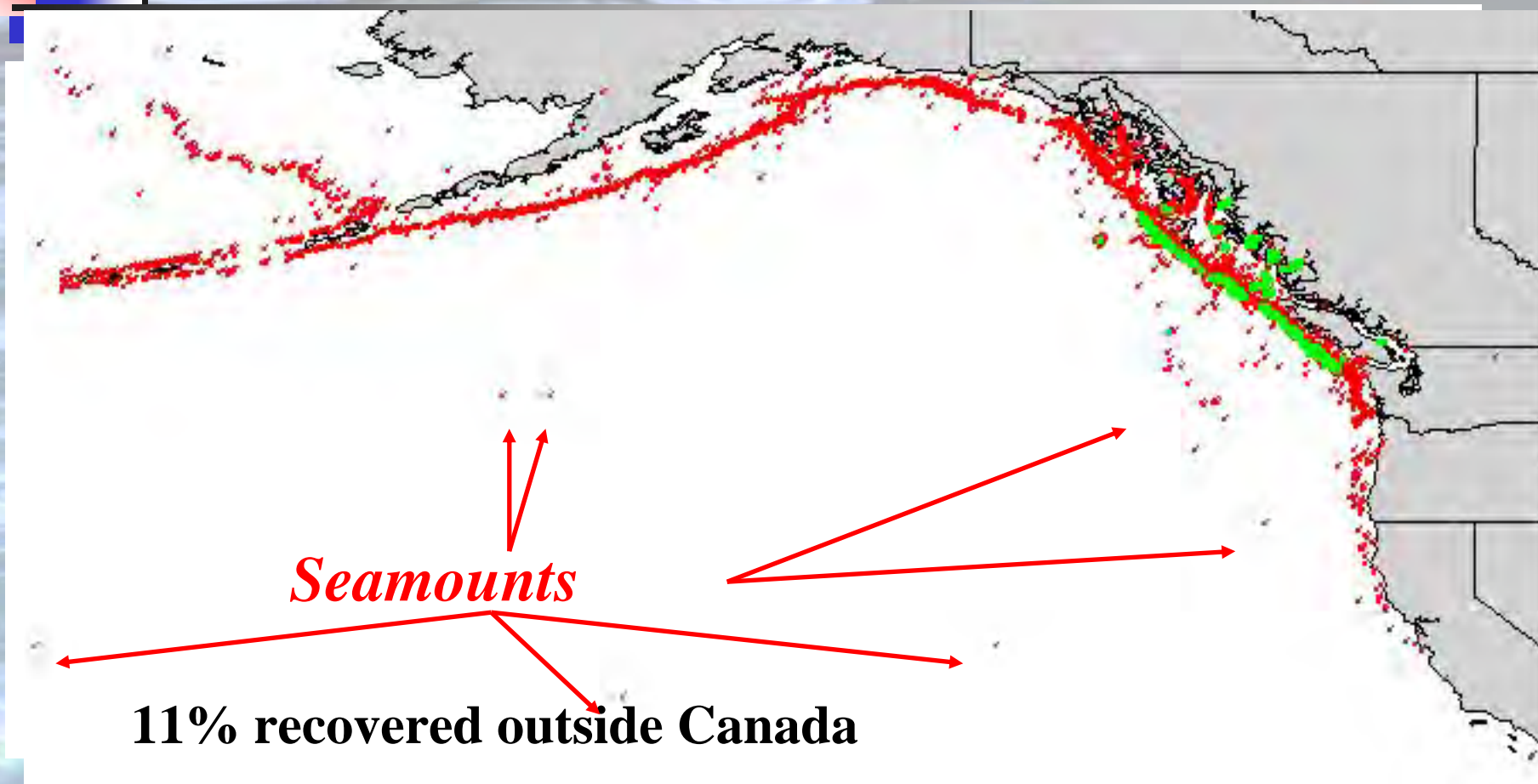
# 2. Sockeye Migration Routes- Queen Charlotte Strait Listening Line



2004 Tag Detections-QCS



# POST & Other Species: Sablefish

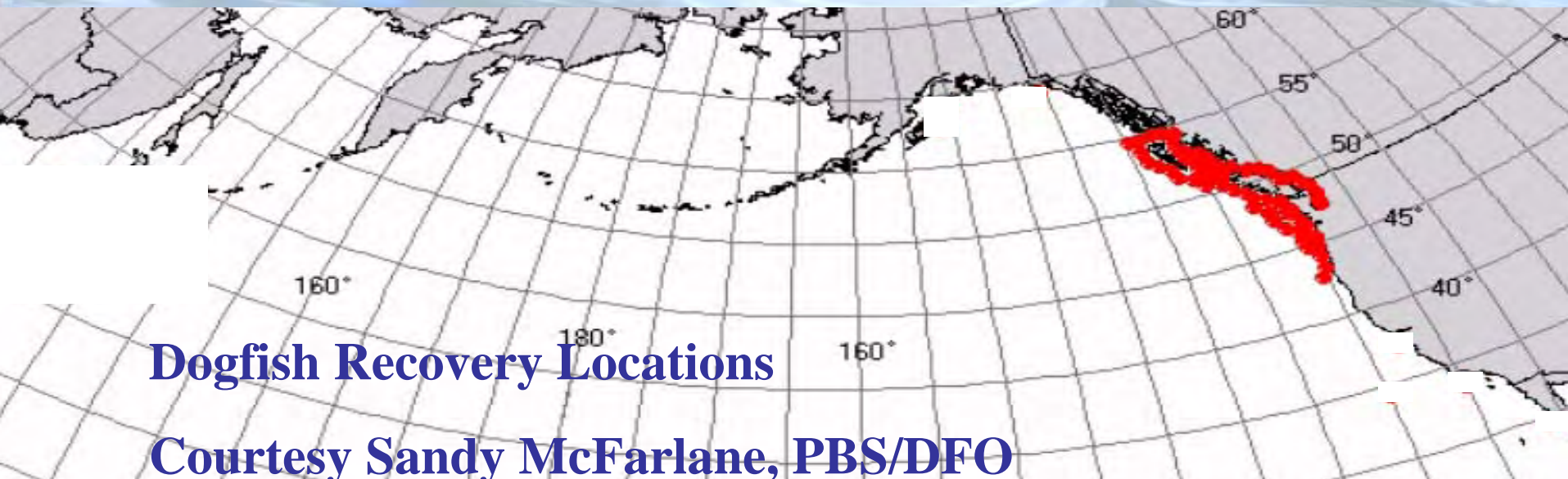


**Sablefish Release (Green) & Recovery (Red) Locations**

**Courtesy Sandy McFarlane, PBS/DFO**

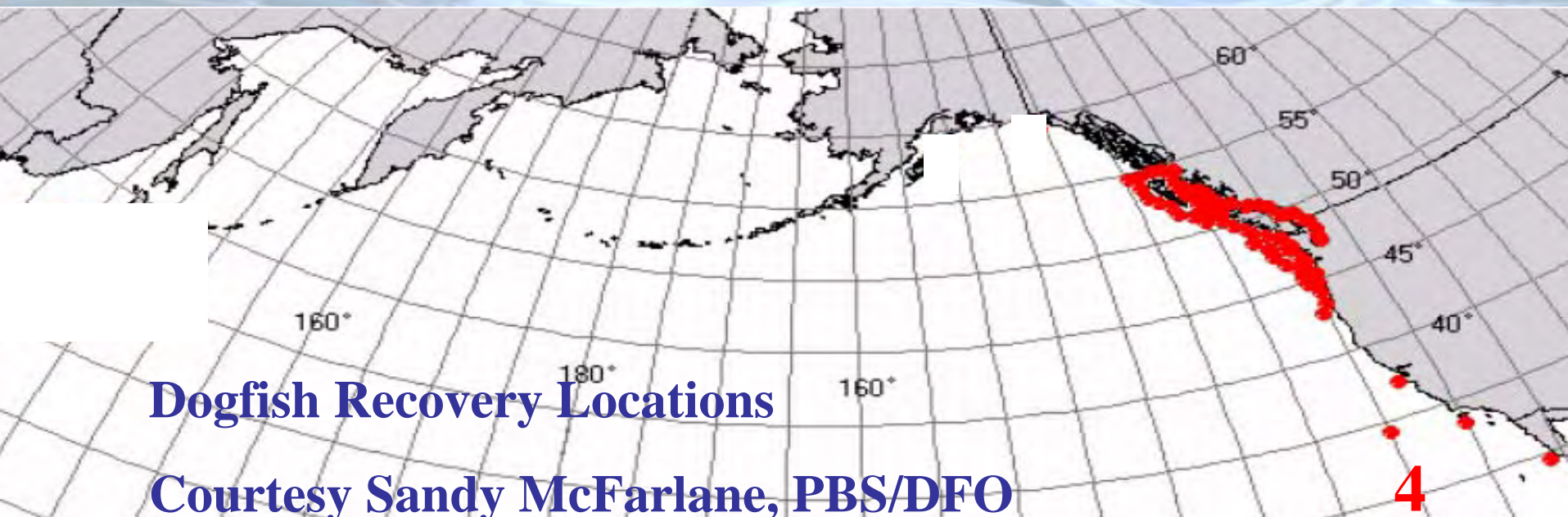
# POST & Other Species: Dogfish

- Dogfish live some 50-80 years
- 100 Million year history
- Most tagged off Vancouver Island recovered nearby
- Some recovered far away--Where??



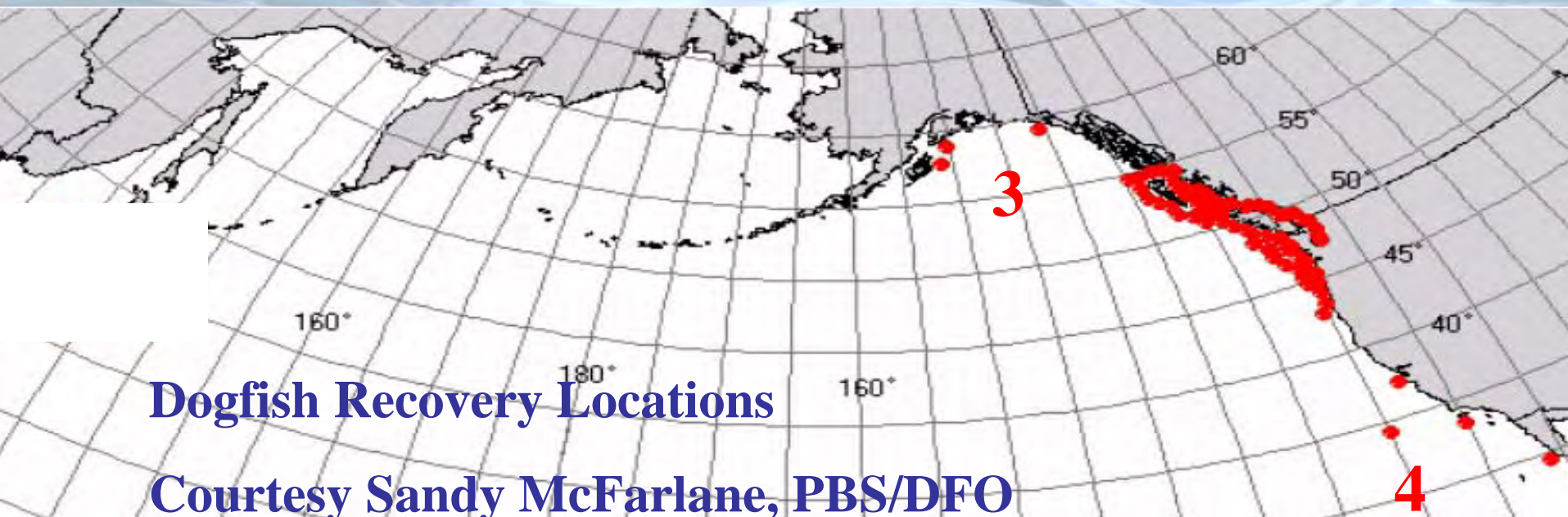
# POST & Other Species: Dogfish

- 4 off California & Baja



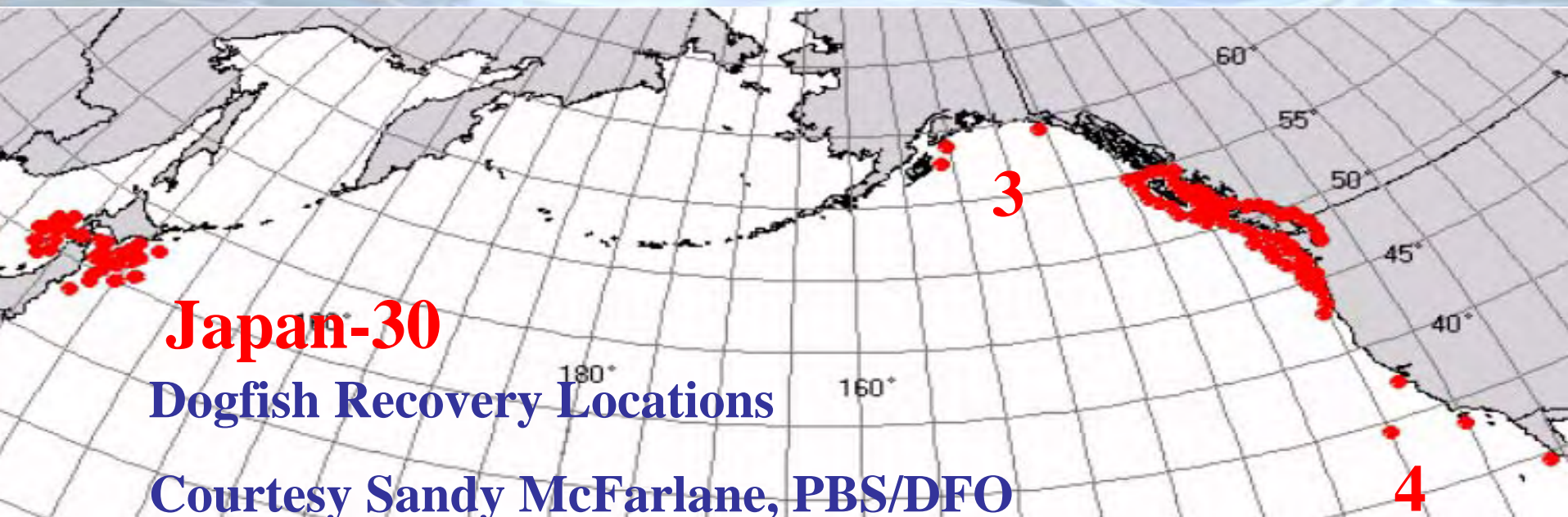
# POST & Other Species: Dogfish

- 4 off California & Baja
- 3 off Alaska
- ... & the rest??



# POST & Other Species: Dogfish

- 30 off Japan, near the Tsugaru Straits
- ... & How did they get there?



# Summary

1. Direct measurement of movements & survival in the ocean is now possible using POST, even for very small fish (10~12 cm)
2. Different genetic populations of a single species (e.g., Sockeye salmon) can have different migration behaviours, explaining how differential mortality can occur in the ocean.

# Summary

3. These behaviors/responses to the ocean & major rivers are now measurable year-round.
4. POST/OTN can change marine fisheries science from an observational science to one based on a much more rigorous quantitative (& potentially) experimental basis.

# Summary

## ❖ Technical Performance:

- Fish survival now at 99.6%, 24 hours post-implantation
- Detection efficiency over the marine array components with defined geometry at 95% (again)
- Detection rates over the large river components reached ca. 100% (finally!) in 2006
- 3 adult Sakinaw sockeye returned with re-activated acoustic tags (work with Chris Wood/DFO)
  - ✓ *Proves that we can now cover both the out-migration & the adult in-migration with one tag (Critical for endangered stocks)*
  - ✓ *Possibly can do the entire ocean life history of salmon with a continuously transmitting tag*

## ❖ Can directly measure Movements

## ❖ Can directly measure Survival

# The 2006/07 POST Array: Science Summary

- FW Survival out of most rivers and early marine survival along coast seems stable between years (most stocks)
- Survival estimates of the same quality as the PIT tag system estimates in the Columbia (Better performance, reasonable cost, much more geographically extensive)
- We are demonstrating the ability to put out permanent year-round engineered arrays that can begin to answer fundamental science questions
- Together with more opportunistic sensor components, this provides the possibility of achieving major advances in marine fisheries science by building both coast-wide and globally compatible arrays (OTN-> Tomorrow's talk)



**Thanks!!**





# *POST's Findings: Conservation Implications for Pacific Salmon*

- I. We are now making critical measurements on key salmon stocks with major conservation concerns
- II. The ocean migration behaviour of different salmon species is not the same
- III. There are differences in migration pathways (speed, route, distribution) of different populations of the same species (e.g Cultus v Sakinaw Sockeye)
- IV. Direct measurement of relative survival in the ocean is now feasible. Some frequent targets of blame (dams/delayed mortality/FW habitat degradation) can now be addressed directly.

A permanent tracking system for salmon and other marine animals is now feasible

*(We can now do this!!)*

- *For young salmon, 4 mo~2 year tags are feasible*
- *For larger animals, tags can have 20+ yr lifespans, yielding multi-year studies on long-lived species such as sharks, cod, and halibut*
- *A complete census of fish moving in & out of large rivers is now feasible (e.g., salmon & sturgeon)*
- *A wide range of other ocean sensors can be supported off this observation system.*



# Where POST is Going:

## Key Points to Keep in Mind

- POST can allow direct experimental study of salmon in the ocean & large rivers, with the response of free-ranging fish studied directly, replacing conjecture with observation (→Sea Lice effects, Late-run behavioural changes).



# Where POST is Going:

## Key Points to Keep in Mind

- In combination, this will lead to an unparalleled ocean observing system telling us how the fish react to the changing ocean environment, where they move to, and where— and perhaps— how they die
- *POST will allow direct study of salmon in the ocean, with the response of free-ranging fish studied directly, replacing conjecture with observation*



Creating positive outcomes  
for future generations.



Kintama Research

# *Why Build a Continental Scale Acoustic Array?*

1. Provide the hard data needed to manage marine fisheries (Find out the things we never could know)
  - ✓ Marine migration studies
  - ✓ Establish areas of ocean residence (“MPAs”)
  - ✓ “At sea” marine survival studies
2. Build the backbone for a coastal GOOS (Global Ocean Observing system)
3. Discovery (Find out the things we never knew we needed to know)!

# Johnstone Strait Attrition

Run Timing Group	Stock	Number Released	Northern Strait of Georgia	Southern Strait of Georgia	Lower Fraser	Derby Reach	Mission
Unknown	Unknown	1	1	1	1	0	0
Early		16	14	12	10	8	8
Mid-Summer		19	16	16	14	13	13
Late-Run		74	58	48	44	40	38
Overall		110	89	77	69	61	59

# Juan de Fuca Attrition

Run Timing Group	Stock	Number Released	Juan de Fuca Strait	Southern Strait of Georgia	Lower Fraser	Derby Reach	Mission
Early		15	12	6	7	4	3
Mid- Summer		12	9	4	4	3	3
Late		12	10	6	6	6	5
USA/Wash St.	Lake Washington	2	2	0	0	0	0
Overall		41	33	16	17	13	11

# WVL Attrition

Run Timing Group	Stock	Number Released	Northern Strait of Georgia	Southern Strait of Georgia	Lower Fraser	Derby Reach	Mission
Early		3	0	2	1	1	0
Mid- Summer		37	0	18	9	8	8
Late		126	1	79	28	24	25
Overall		167	1	100	38	33	33

BPA

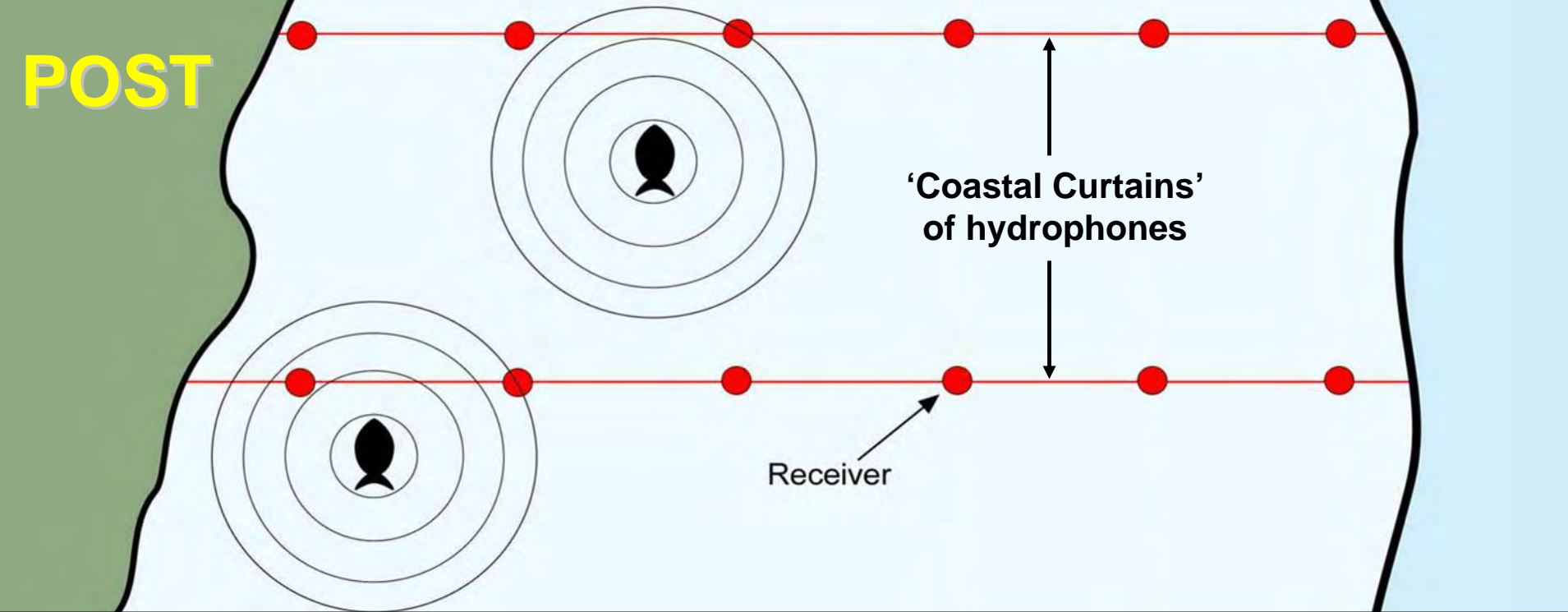
# Juan de Fuca Releases: *Median travel time (days)*

Juan de Fuca Releases	Juan de Fuca		Southern Strait of Georgia		Lower Fraser		Derby Reach		Mission	
Run Timing Group	N	Travel Time	N	Travel Time	N	Travel Time	N	Travel Time	N	Travel Time
Early	12	1.60	6	5.04	7	5.64	4	7.46	3	8.03
Mid-Summer	9	2.25	4	7.08	4	7.95	3	9.01	3	9.48
Late	10	2.44	6	6.50	6	8.14	6	12.72	5	12.84

# Route of Travel and "Survival"

Release Area	Number Released	Lippy Point	Juan de Fuca	Queen Charlotte Strait	Northern Strait of Georgia	Southern Strait of Georgia	Fraser River Mouth
QCI	196	1	2	11	2	2	4
JS	109	0	0	0	88	76	69
JdF	41	0	33	0	0	16	18
WVL	167	0	0	0	1	100	38

**POST**



**OTN gives biological & physical data, including acoustic uploads & archival downloads**

